

CLAIMS

What is claimed is:

1 1. An apparatus that provides a radio frequency
2 energy to a probe placed in contact with a cornea to
3 perform a medical procedure, comprising:
4 a radio frequency circuit that delivers a radio
5 frequency energy to the cornea through the probe; and,
6 a regulator circuit that controls the radio frequency
7 energy delivered to the cornea during the medical
8 procedure.

1 2. The apparatus of claim 1, further comprising a
2 sensing circuit that senses a change in a physiology of the
3 cornea during the medical procedure and provides a feedback
4 to said regulator circuit.

1 3. The apparatus of claim 2, wherein said sensing
2 circuit senses a current delivered to the cornea.

1 4. The apparatus of claim 2, wherein said sensing
2 circuit senses a voltage delivered to the cornea.

1 5. The apparatus of claim 2, wherein said sensing
2 circuit senses a temperature of the cornea.

1 6. The apparatus of claim 2, wherein said sensing
2 circuit senses an impedance of the cornea.

1 7. The apparatus of claim 2, wherein said sensing
2 circuit senses a moisture of the cornea.

1 8. The apparatus of claim 1, wherein said regulator
2 circuit controls the delivery of the radio frequency energy
3 about a set-point.

1 9. The apparatus of claim 1, wherein said regulator
2 circuit controls the delivery of the radio frequency energy
3 about a set-curve.

1 10. The apparatus of claim 2, wherein said regulator
2 circuit determines a profile of a physiological parameter

3 and regulates the radio frequency energy delivered to the
4 cornea in accordance with the profile.

1 11. The apparatus of claim 10, wherein the profile is
2 an impedance profile.

1 12. The apparatus of claim 10, wherein the profile is
2 a temperature profile.

1 13. The apparatus of claim 10, wherein the profile is
2 a moisture profile.

1 14. The apparatus of claim 10, wherein said regulator
2 circuit decreases the radio frequency energy if the profile
3 includes an increase in impedance beyond a threshold level
4 during the medical procedure.

1 15. The apparatus of claim 10, wherein said regulator
2 circuit terminates delivery of the radio frequency energy
3 if the profile exceeds a threshold level during the medical
4 procedure.

1 16. The apparatus of claim 10, wherein said regulator
2 circuit terminates delivery of the radio frequency energy
3 if the profile includes a slope that exceeds a threshold
4 level during the medical procedure.

1 17. The apparatus of claim 16, wherein said regulator
2 circuit modulates a duration of the delivery of the radio
3 frequency energy.

1 18. The apparatus of claim 17, wherein said duration
2 is modulated in response to changes in a profile of the
3 physiological parameter.

1 19. The apparatus of claim 18, wherein the
2 physiological parameter is an impedance.

1 20. The apparatus of claim 18, wherein the
2 physiological parameter is a temperature.

1 21. The apparatus of claim 18, wherein the
2 physiological parameter is a tissue moisture.

1 22. The apparatus of claim 1, wherein said regulator
2 circuit modulates a level of the radio frequency energy.

1 23. An apparatus that provides a radio frequency
2 energy to a probe placed in contact with a cornea to
3 perform a medical procedure, comprising:
4 a radio frequency circuit that delivers a radio
5 frequency energy to the cornea through the probe; and,
6 regulator circuit means for controlling the radio
7 frequency energy delivered to cornea during the medical
8 procedure.

1 24. The apparatus of claim 23, further comprising
2 sensing circuit means for sensing a change in a physiology
3 of the cornea during the medical procedure and providing a
4 feedback to said regulator circuit.

1 25. The apparatus of claim 24, wherein said sensing
2 circuit means senses a current delivered to the cornea.

1 26. The apparatus of claim 24, wherein said sensing
2 circuit means senses a voltage delivered to the cornea.

1 27. The apparatus of claim 24, wherein said sensing
2 circuit means senses a temperature of the cornea.

1 28. The apparatus of claim 24, wherein said sensing
2 circuit means senses an impedance of the cornea.

1 29. The apparatus of claim 24, wherein said sensing
2 circuit means senses a moisture of the cornea.

1 30. The apparatus of claim 23, wherein said regulator
2 circuit means controls the delivery of the radio frequency
3 energy about a set-point.

1 31. The apparatus of claim 23, wherein said regulator
2 circuit means controls the delivery of the radio frequency
3 energy about a set-curve.

1 32. The apparatus of claim 24, wherein said regulator
2 circuit means determines a profile of a physiological

3 parameter and regulates the radio frequency energy
4 delivered to the cornea in accordance with the profile.

1 33. The apparatus of claim 32, wherein the profile is
2 an impedance profile.

1 34. The apparatus of claim 32, wherein the profile is
2 a temperature profile.

1 35. The apparatus of claim 32, wherein the profile is
2 a moisture profile.

1 36. The apparatus of claim 32, wherein said regulator
2 circuit means decreases the radio frequency energy if the
3 profile includes an increase in impedance beyond a
4 threshold level during the medical procedure.

1 37. The apparatus of claim 32, wherein said regulator
2 circuit means terminates delivery of the radio frequency
3 energy if the profile exceeds a threshold level during the
4 medical procedure.

1 38. The apparatus of claim 32, wherein said regulator
2 circuit means terminates delivery of the radio frequency
3 energy if the profile includes a slope that exceeds a
4 threshold level during the medical procedure.

1 39. The apparatus of claim 23, wherein said regulator
2 circuit means modulates a duration of the delivery of the
3 radio frequency energy.

1 40. The apparatus of claim 39, wherein said duration
2 is modulated in response to changes in a profile of the
3 physiological parameter.

1 41. The apparatus of claim 40, wherein the
2 physiological parameter is an impedance.

1 42. The apparatus of claim 40, wherein the
2 physiological parameter is a temperature.

1 43. The apparatus of claim 40, wherein the
2 physiological parameter is a tissue moisture.

1 44. The apparatus of claim 23, wherein said regulator
2 circuit means modulates a level of the radio frequency.
3 energy.

1 45. A method for performing a medical procedure on a
2 cornea, comprising:

3 placing a probe in contact with a cornea;

4 delivering a radio frequency energy to the cornea
5 through the probe; and,

6 regulating the radio frequency energy delivered to
7 cornea during the medical procedure.

1 46. The method of claim 45, further comprising sensing
2 and feeding back a change in a physiology of the cornea
3 during the medical procedure and regulating the radio
4 frequency energy delivered to the cornea as a function of
5 the feedback.

1 47. The method of claim 46, wherein a current
2 delivered to the cornea is sensed during the medical
3 procedure.

1 48. The method of claim 46, wherein a voltage
2 delivered to the cornea is sensed during the medical
3 procedure.

1 49. The method of claim 46, wherein a temperature of
2 the cornea is sensed during the medical procedure.

1 50. The method of claim 46, wherein an impedance of
2 the cornea is sensed during the medical procedure.

1 51. The method of claim 46, wherein said a moisture of
2 the cornea is sensed during the medical procedure.

1 52. The method of claim 45, wherein the radio
2 frequency energy is regulated about a set-point.

1 53. The method of claim 45, wherein the radio
2 frequency energy is regulated about a set-curve.

1 54. The method of claim 46, wherein a profile of a
2 physiological parameter is determined and the radio

3 frequency energy delivered to the cornea is regulated in
4 accordance with the profile.

1 55. The method of claim 54, wherein the profile is an
2 impedance profile.

1 56. The method of claim 54, wherein the profile is a
2 temperature profile.

1 57. The method of claim 54, wherein the profile is a
2 moisture profile.

1 58. The method of claim 54, wherein regulating
2 includes decreasing the radio frequency energy if the
3 profile includes an increase in impedance beyond a
4 threshold level during the medical procedure.

1 59. The method of claim 54, wherein regulating
2 includes terminating delivery of the radio frequency energy
3 if the profile exceeds a threshold level during the medical
4 procedure.

1 60. The method of claim 54, wherein regulating
2 includes terminating delivery of the radio frequency energy
3 if the profile includes a slope that exceeds a threshold
4 level during the medical procedure.

1 61. The method of claim 45, wherein regulating
2 includes modulating a duration of the delivery of the radio
3 frequency energy.

1 62. The method of claim 61, wherein the duration is
2 modulated in response to changes in a profile of the
3 physiological parameter.

1 63. The method of claim 61, wherein the physiological
2 parameter is an impedance.

1 64. The method of claim 61, wherein the physiological
2 parameter is a temperature.

1 65. The method of claim 61, wherein the physiological
2 parameter is a tissue moisture.

1 66. The method of claim 45, wherein regulating
2 includes modulating a level of the radio frequency energy.

1 67. An apparatus that provides a radio frequency
2 energy to a probe placed in contact with a cornea to
3 perform a medical procedure, comprising:
4 a radio frequency circuit that delivers a radio
5 frequency energy to the cornea through the probe; and,
6 a sensing circuit that senses a change in a physiology
7 of the cornea while said radio frequency circuit delivers
8 the radio frequency energy to the cornea.

1 68. The apparatus of claim 67, wherein said sensing
2 circuit senses a current delivered to the cornea.

1 69. The apparatus of claim 67, wherein said sensing
2 circuit senses a voltage delivered to the cornea.

1 70. The apparatus of claim 67, wherein said sensing
2 circuit senses a temperature of the cornea.

1 71. The apparatus of claim 67, wherein said sensing
2 circuit senses an impedance of the cornea.

1 72. The apparatus of claim 67, wherein said sensing
2 circuit senses a moisture of the cornea.

1 73. An apparatus that provides a radio frequency
2 energy to a probe placed in contact with a cornea to
3 perform a medical procedure, comprising:
4 a radio frequency circuit that delivers a radio
5 frequency energy to the cornea through the probe; and,
6 sensing means for sensing a change in a physiology of
7 the cornea while said radio frequency circuit delivers the
8 radio frequency energy delivered to the cornea.

1 74. The apparatus of claim 73, wherein said sensing
2 means senses a current delivered to the cornea.

1 75. The apparatus of claim 73, wherein said sensing
2 means senses a voltage delivered to the cornea.

1 76. The apparatus of claim 73, wherein said sensing
2 means senses a temperature of the cornea.

1 77. The apparatus of claim 73, wherein said sensing
2 means senses an impedance of the cornea.

1 78. The apparatus of claim 73, wherein said sensing
2 means senses an impedance of the cornea.

1 79. A method for performing a medical procedure on a
2 cornea, comprising:
3 placing a probe in contact with a cornea;
4 delivering a radio frequency energy to the cornea
5 through the probe; and,
6 sensing a change in a physiology of the cornea while
7 the radio frequency energy is delivered to the cornea.

1 80. The method of claim 79, wherein a current
2 delivered to the cornea is sensed while the radio frequency
3 energy is delivered to the cornea.

1 81. The method of claim 79, wherein a voltage
2 delivered to the cornea is sensed while the radio frequency
3 energy is delivered to the cornea.

1 82. The method of claim 79, wherein an impedance of
2 the cornea is sensed while the radio frequency energy is
3 delivered to the cornea.

1 83. The method of claim 79, wherein a temperature of
2 the cornea is sensed while the radio frequency energy is
3 delivered to the cornea.

1 84. The method of claim 79, wherein a moisture of the
2 cornea is sensed while the radio frequency energy is
3 delivered to the cornea.

1 85. An apparatus that provides a non-thermal energy to
2 a cornea through a probe to perform a medical procedure
3 that denatures collagen tissue and reshapes the cornea,
4 comprising:

5 an energy circuit that delivers a non-thermal energy to
6 the cornea through the probe; and,

7 a regulator circuit that controls the non-thermal
8 energy delivered to the cornea during the medical
9 procedure.

1 86. The apparatus of claim 85, wherein the non-thermal
2 energy is in a microwave frequency range.

1 87. The apparatus of claim 85, wherein the non-thermal
2 energy is in an ultrasonic frequency range.

1 88. The apparatus of claim 85, wherein the non-thermal
2 energy is light.

1 89. The apparatus of claim 85, wherein the non-thermal
2 energy is direct current.

1 90. The apparatus of claim 85, further comprising a
2 sensing circuit that senses a change in a physiology of the
3 cornea during the medical procedure and provides a feedback
4 to said regulator circuit.

1 91. The apparatus of claim 90, wherein said sensing
2 circuit senses a current delivered to the cornea.

1 92. The apparatus of claim 90, wherein said sensing
2 circuit senses a voltage delivered to the cornea.

1 93. The apparatus of claim 90, wherein said sensing
2 circuit senses a temperature of the cornea.

1 94. The apparatus of claim 90, wherein said sensing
2 circuit senses an impedance of the cornea.

1 95. The apparatus of claim 90, wherein said sensing
2 circuit senses an optical characteristic of the cornea.

1 96. The apparatus of claim 85, wherein said regulator
2 circuit controls the delivery of the non-thermal energy
3 about a set-point.

1 97. The apparatus of claim 85, wherein said regulator
2 circuit controls the delivery of the non-thermal energy
3 about a set-curve.

1 98. The apparatus of claim 90, wherein said regulator
2 circuit determines a profile of a physiological parameter

3 and regulates the non-thermal energy delivered to the
4 cornea in accordance with the profile.

1 99. The apparatus of claim 98, wherein said regulator
2 circuit decreases the non-thermal energy if the profile
3 displays changes indicative of necrotic collagen structural
4 modification beyond a threshold level during the medical
5 procedure.

1 100. The apparatus of claim 98, wherein said regulator
2 circuit terminates delivery of the non-thermal energy if
3 the profile exceeds a threshold level during the medical
4 procedure.

1 101. The apparatus of claim 98, wherein said regulator
2 circuit terminates delivery of the non-thermal energy if
3 the profile includes a slope that exceeds a threshold level
4 during the medical procedure.

1 102. The apparatus of claim 85, wherein said regulator
2 circuit modulates a duration of the delivery of the non-
3 thermal energy.

1 103. The apparatus of claim 85, wherein said regulator
2 circuit modulates a level of the non-thermal energy.

1 104. An apparatus that provides a non-thermal energy to
2 a cornea through a probe to perform a medical procedure
3 that denatures collagen tissue and reshapes the cornea,
4 comprising:

5 an energy circuit that delivers a non-thermal energy to
6 the cornea through the probe; and,

7 regulator circuit means for controlling the non-thermal
8 energy delivered to cornea during the medical procedure.

1 105. The apparatus of claim 104, wherein the non-
2 thermal energy is in a microwave frequency range.

1 106. The apparatus of claim 104, wherein the non-
2 thermal energy is in an ultrasonic frequency range.

1 107. The apparatus of claim 104, wherein the non-
2 thermal energy is light.

1 108. The apparatus of claim 104, wherein the non-
2 thermal energy is direct current.

1 109. The apparatus of claim 104, further comprising
2 sensing circuit means for sensing a change in a physiology
3 of the cornea during the medical procedure and providing a
4 feedback to said regulator circuit.

1 110. The apparatus of claim 109, wherein said sensing
2 circuit means senses a current delivered to the cornea.

1 111. The apparatus of claim 109, wherein said sensing
2 circuit means senses a voltage delivered to the cornea.

1 112. The apparatus of claim 109, wherein said sensing
2 circuit means senses a temperature of the cornea.

1 113. The apparatus of claim 109, wherein said sensing
2 circuit means senses an impedance of the cornea.

1 114. The apparatus of claim 109, wherein said sensing
2 circuit means senses an optical characteristic of the
3 cornea.

1 115. The apparatus of claim 104, wherein said regulator
2 circuit means controls the delivery of the non-thermal
3 energy about a set-point.

1 116. The apparatus of claim 104, wherein said regulator
2 circuit means controls the delivery of the non-thermal
3 energy about a set-curve.

1 117. The apparatus of claim 109, wherein said regulator
2 circuit means determines a profile of a physiological
3 parameter and regulates the non-thermal energy delivered to
4 the cornea in accordance with the profile.

1 118. The apparatus of claim 117, wherein said regulator
2 circuit means decreases the non-thermal energy if the
3 profile displays changes indicative of necrotic collagen
4 structural modification beyond a threshold level during the
5 medical procedure.

1 119. The apparatus of claim 114, wherein said regulator
2 circuit means terminates delivery of the non-thermal energy
3 if the profile exceeds a threshold level during the medical
4 procedure.

1 120. The apparatus of claim 114, wherein said regulator
2 circuit means terminates delivery of the non-thermal energy
3 if the profile includes a slope that exceeds a threshold
4 level during the medical procedure.

1 121. The apparatus of claim 104, wherein said regulator
2 circuit means modulates a duration of the delivery of the
3 non-thermal energy.

1 122. The apparatus of claim 104, wherein said regulator
2 circuit modulates a level of the non-thermal energy.

1 123. A method for performing a medical procedure on a
2 cornea, comprising:
3 contacting a cornea with a probe;

4 delivering a non-thermal energy to the cornea through
5 the probe to denature collagen tissue and reshape the
6 cornea; and,
7 regulating the non-thermal energy delivered to cornea
8 during the medical procedure.

1 124. The method of claim 123, wherein the non-thermal
2 energy is in a microwave frequency range.

1 125. The method of claim 123, wherein the non-thermal
2 energy is in an ultrasonic frequency range.

1 126. The method of claim 123, wherein the non-thermal
2 energy is light.

1 127. The method of claim 123, wherein the non-thermal
2 energy is direct current.

1 128. The method of claim 123, further comprising
2 sensing a change in a physiology of the cornea during the
3 medical procedure and regulating the non-thermal energy
4 delivered to the cornea as a function of the feedback.

1 129. The method of claim 128, wherein a current
2 delivered to the cornea is sensed during the medical
3 procedure.

1 130. The method of claim 128, wherein a voltage
2 delivered to the cornea is sensed during the medical
3 procedure.

1 131. The method of claim 128, wherein a temperature of
2 the cornea is sensed during the medical procedure.

1 132. The method of claim 128, wherein an impedance of
2 the cornea is sensed during the medical procedure.

1 133. The method of claim 128, wherein an optical
2 characteristic of the cornea is sensed during the medical
3 procedure.

1 134. The method of claim 123, wherein the non-thermal
2 energy is regulated about a set-point.

1 135. The method of claim 123, wherein the non-thermal
2 energy is regulated about a set-curve.

1 136. The method of claim 128, wherein a profile of a
2 physiological parameter is determined and the non-thermal
3 energy delivered to the cornea is regulated in accordance
4 with the profile.

1 137. The method of claim 136, wherein regulating
2 includes decreasing the non-thermal energy if the profile
3 displays changes indicative of necrotic collagen structural
4 modification beyond a threshold level during the medical
5 procedure.

1 138. The method of claim 136, wherein regulating
2 includes terminating delivery of the non-thermal energy if
3 the profile exceeds a threshold level during the medical
4 procedure.

1 139. The method of claim 136, wherein regulating
2 includes terminating delivery of the non-thermal energy if

3 the profile includes a slope that exceeds a threshold level
4 during the medical procedure.

1 140. The method of claim 123, wherein regulating
2 includes modulating a duration of the delivery of the non-
3 thermal energy.

1 141. The method of claim 123, wherein regulating
2 includes modulating a level of the non-thermal energy.

1 142. An apparatus that provides a non-thermal energy to
2 a cornea through a probe to perform a medical procedure
3 that denatures collagen tissue and reshapes the cornea,
4 comprising:

5 a energy circuit that delivers a non-thermal energy to
6 the cornea through the probe; and,

7 a sensing circuit that senses a change in a physiology
8 of the cornea while said energy circuit delivers the non-
9 thermal energy to the cornea.

1 143. The apparatus of claim 142, wherein the non-
2 thermal energy is in a microwave frequency range.

1 144. The apparatus of claim 142, wherein the non-
2 thermal energy is in an ultrasonic frequency range.

1 145. The apparatus of claim 142, wherein the non-
2 thermal energy is light.

1 146. The apparatus of claim 142, wherein the non-
2 thermal energy is direct current.

1 147. The apparatus of claim 142, wherein said sensing
2 circuit senses a current delivered to the cornea.

1 148. The apparatus of claim 142, wherein said sensing
2 circuit senses a voltage delivered to the cornea.

1 149. The apparatus of claim 142, wherein said sensing
2 circuit senses a temperature of the cornea.

1 150. The apparatus of claim 142, wherein said sensing
2 circuit senses an impedance of the cornea.

1 151. The apparatus of claim 142, wherein said sensing
2 circuit senses an optical characteristic of the cornea.

1 152. An apparatus that provides a non-thermal energy to
2 a cornea through a probe to perform a medical procedure to
3 denature collagen tissue and reshape the cornea,
4 comprising:

5 an energy circuit that delivers a non-thermal energy to
6 the cornea through the probe; and,

7 sensing means for sensing a change in a physiology of
8 the cornea while said energy circuit delivers the non-
9 thermal energy delivered to the cornea.

1 153. The apparatus of claim 152, wherein the non-
2 thermal energy is in a microwave frequency range.

1 154. The apparatus of claim 152, wherein the non-
2 thermal energy is in an ultrasonic frequency range.

1 155. The apparatus of claim 152, wherein the non-
2 thermal energy is light.

1 156. The apparatus of claim 152, wherein the non-
2 thermal energy is direct current.

1 157. The apparatus of claim 152, wherein said sensing
2 means senses a current delivered to the cornea.

1 158. The apparatus of claim 152, wherein said sensing
2 means senses a voltage delivered to the cornea.

1 159. The apparatus of claim 152, wherein said sensing
2 means senses a temperature of the cornea.

1 160. The apparatus of claim 152, wherein said sensing
2 means senses an impedance of the cornea.

1 161. The apparatus of claim 152, wherein said sensing
2 means senses an optical characteristic of the cornea.

1 162. A method for performing a medical procedure on a
2 cornea, comprising:

3 contacting a cornea with a probe;

4 delivering a non-thermal energy to the cornea through
5 the probe; and,

6 sensing a change in a physiology of the cornea while
7 the non-thermal energy is delivered to the cornea.

1 163. The method of claim 162, wherein the non-thermal
2 energy is in a microwave frequency range.

1 164. The method of claim 162, wherein the non-thermal
2 energy is in an ultrasonic frequency range.

1 165. The method of claim 162, wherein the non-thermal
2 energy is light.

1 166. The method of claim 162, wherein the non-thermal
2 energy is direct current.

1 167. The method of claim 162, wherein a current
2 delivered to the cornea is sensed while the non-thermal
3 energy is delivered to the cornea.

1 168. The method of claim 162, wherein a voltage
2 delivered to the cornea is sensed while the non-thermal
3 energy is delivered to the cornea.

1 169. The method of claim 162, wherein a temperature of
2 the cornea is sensed while the non-thermal energy is
3 delivered to the cornea.

1 170. The method of claim 162, wherein an optical
2 characteristic of the cornea is sensed while the non-
3 thermal energy is delivered to the cornea.